

# Mechanical Energy Harvesting using Piezo-Triboelectric Nanogenerator

Dr. Arun Thomas, Sam Vincent, Ranjana. A, Reena Thomas, Seethal Babu

Department of Computer Science, Sahrdya College of Engineering, Thrissur, Kerala, India

## ABSTRACT

As there is a rapid growth of portable electronic gadgets, sustainable energy sources for these devices become indispensable. The possibility to power them by energy harvested from renewable sources have to be found. Triboelectric nanogenerators are the most viable solution to harvest energy from low frequency mechanical motions. A TENG is an energy harvesting device that converts external mechanical energy into electricity by a conjunction of contact electrification and electrostatic induction and this electricity is used to power our electronic gadgets wirelessly by using wireless module and piezoelectric nanogenerators also do the same on applying the pressure. This device opens a new horizons for ways to produce and store wasted energy from our surroundings and in a near future to power wireless sensors and electronic gadgets using hybrid piezo-triboelectric nanogenerators.

**KEYWORDS:** Triboelectric nanogenerator (TENG), Piezo-Tribo electric Nanogenerator (PTENG), Hybrid nanogenerator, Polytetrafluoroethylene (PTFE)

**How to cite this paper:** Dr. Arun Thomas | Sam Vincent | Ranjana. A | Reena Thomas | Seethal Babu "Mechanical Energy Harvesting using Piezo-Triboelectric Nanogenerator"

Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-4, June 2020, pp.967-971, URL: [www.ijtsrd.com/papers/ijtsrd31307.pdf](http://www.ijtsrd.com/papers/ijtsrd31307.pdf)



Copyright © 2020 by author(s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



## I. INTRODUCTION

Energy plays a key role within the method of economic process of a nation. The economic development of any country depends on the organised development of its power resources. Energy is additionally indispensable for agriculture, transport, business and domestic needs. In fact, electricity has such a good vary of applications in trendy economic development that its per capita consumption is, to an excellent extent, associate index of the fabric advancement of the country. Energy is that the capability for doing helpful work. It's an important input for economic process. This energy is employed within the style of power, thermal energy, light, energy and energy. The employment and price of energy affects every folks daily of our lives. Several problems arise from the employment of energy: greenhouse emission emissions, acid rain, temperature change, dependency on depleting provides of fossil fuels particularly from politically unstable regions of the globe. Today, eighty share of the world's electrical production comes from fossil and nuclear fuels, and nearly all transportation is fuelled by liquid crude. In recent years, the triboelectric nanogenerator (TENG) has developed as a capable thought for the employment of multiple styles of renewable energy within the close setting. A triboelectric nanogenerator depends on contact electrification not to mention electricity induction between 2 media for energy conversion. TENGs are recommended to possess higher energy gathering efficiencies within the low-frequency vary. This development is especially very important as a result of, for close environmental sources, most of the encompassing

media oscillates with low to medium frequency motion. Several efforts are dedicated to exploring advanced TENG styles by causing electron flow from coalescing electricity induction throughout contact electrification. These styles have attracted interest for microscale energy gathering devices.

The adjustive and integrative options of TENGs will give vital help to wind-based energy solutions with multiple hybrid blue energy sources, like wind-wave, wind-solar, and water-solar. Therefore, the aptitude to harvest blue energy, particularly with giant networks beneath comparatively weak water waves and air currents, puts TENGs and PENGs at the forefront of developing subsequent generation of property energy sources.

To meet the good need for renewable and property power sources, energy within the environment is widely used for electricity generation. In the planned system a piezo-triboelectric nanogenerators and electromyogram were hybridized to reap the human energy. There are varied energy sources which will be harvested to power electronic devices. These embody alternative energy, energy, thermal energy and energy etc. however with the diminution of energy sources and therefore it would like for victimization cleaner energy, alternatives should be found. User motion may even be recorded and discriminated victimization this energy cell.

During traditional walking, it may record the steps. With none battery. A wireless signal transmitter may additionally work once driven by the energy cell. Once many cycles of vibration, it may send an indication that will be received by a distant receiver. Afterwards, the nanogenerator was used to charge a little electronic gadgets. Throughout vibration, the collected energy was hold on in a very capacitance, serving as a buffer. Tiny electronic gadgets are going to be wirelessly charged victimization the wireless module in build within the shoe sole.

## II. PROBLEM DEFINITION

Energy is that the basis of all activity. Without energy, nothing moves nor transforms and then a sustainable society will solely exist supported a property energy system. tho' extremely focused sorts of energy found in nature permit the free time to form ever additional subtle tools quickly (and or win wars), their use isn't sustainable. In general, the follow of extracting naturally focused energy causes four reticulate basic problems: Disrupting natural energy flows, Depletion, Centralization, and Resource wars.

Energy is a vital element of all development programs. While not energy, trendy life would stop to exist. We'd like energy to take care of physical comfort in abundant of the globe, to win and manufacture helpful materials and artefacts, for transport, for communications, for agriculture and for trade generally. Energy is created obtainable by harnessing natural energy flows like moving water, radiation and wind, and chiefly by victimization fuels like wood, coal, oil, gas and metallic element. However, the harnessing and utilization of energy is related to worrying issues, namely, depletion and environmental harm. In this, we examine these environmental issues.

Today, our energy system is predicated on extracting highly focused forms of energy we discover in nature, like fossil fuels, massive rivers and waterfalls, burning trees and rending metallic element. Sadly, our energy system is dysfunctional as a result of extremely focused kinds of energy each briefly provide and play important roles within the scheme. as a result of energy is that the basis of all activity this disfunction propagates throughout all of our activity and interactions with nature, manifesting as issues basically everywhere: deforestation, ocean natural process, mass poorness, pollution of all kinds, diseases, deficiency disease, water level depletion, community sprawl, corruption, to call some in no explicit order.

Nowadays the amount of transportable and wearable electronic devices area unit increasing day by day. The amount of connected devices all round the world is anticipated to be eighty billion by 2025. Of these devices use battery as a supply of energy. Once the battery charge is lost, the operating of those gadgets fail. For determination these energy issues we want a much better and economical energy harvest home system. This may mitigate the necessity of disposal and management of those batteries. It's conjointly vital that the power made from the mechanical motions ought to be adequate to charge the electronic devices.

## III. MOTIVATION

Nowadays, the renewable energy (RE) is turning into associate immense business in most of states within the world. There are 2 factors have forced this business

developed. First, the general public awareness of relative benefits provided by RE. Second, the restructuring of the electricity provide business thanks to the foundations and regulation obligatory by the govt.

With the fast development of moveable natural philosophy and detector networks, researchers have dedicated intensive efforts to finding out property mobile energy supply with the output level from  $\mu\text{W}$  to  $\text{mW}$ . Currently, the foremost usually utilised approach is to power them by energy storage units like batteries or capacitors. However, there are 2 major shortcomings. The primary one is that the restricted life, so they cannot sustainably drive the physical science. The other is that the problem of disposal, that might cause serious environmental drawback if not handled properly.

As an alternate manner, generators supported electricity, pyro electrical, associated triboelectric effects are developed to power natural philosophy property alone by harvest small-scale energy from a close surroundings. Among nanogenerators, triboelectric nanogenerator has been a hot topic in recent years thanks to its high energy output and high conversion potency, with large innovations pushing forward its development. Within the current work, we tend to specializing in triboelectric nanogenerator and

also the corresponding power grid to be the property and freelance energy supply for tiny natural philosophy. The operating mechanism of a TENG relies on the coupling of tribo electrification and electricity induction.

### A. Objectives of the device

- Contact electrification is as well as electricity induction in developing piezo-triboelectric nanogenerator as a replacement energy technology.
- Power-generating sole with inbuilt versatile multi-layered triboelectric nanogenerators that harvest mechanical pressure throughout walking.
- To integrate triboelectric and electricity materials with a high strength structural material with the potential to be integrated in a whole structure or unit.
- To modify the combination of piezo-triboelectric gathering systems in electronic gadgets, wherever the vibrations inflicting strain will manufacture effective contact separation movements.
- Attempt in applying energy-harvesting technology for self-powered physical science in our everyday life, which is able to have broad impact on people's living vogue within the close to future.
- To overcome the matter of skimpy energy by gathering the energy and so convert it into power for higher charging purpose.

## IV. LITERATURE SURVEY

*A. a unique arch-shaped hybrid composite triboelectric generator victimisation carbonfiber strengthened polymers.*

To supply energy to autonomous low-power physical science has spurred interest in triboelectric materials. Associate arch formed hybrid carbonfiber strengthened polymer (CFRP) composite triboelectric device is made-up, that employs a curving higher copper conductor and a flat lower polyimide layer, each of that area unit combined with CFRP materials.

Structural composites associated triboelectric materials to fabricate an arc-shaped hybrid CFRP composite-based triboelectric device. The system utilized the aeolotropic thermal enlargement of CFRP to make a curving higher conductor made from copper. A centrosymmetric composite design was wont to produce a flat lower polyimide conductor. This device aimed to be used as a triboelectric harvest home energy supply for self-powered structures. We've got been able to manually turn out a voltage up to 300 mV, which may charge a condenser of 0.11 to 250 mV. Any enhancements were conducted on a second device, the same as the primary one, during which glass layers were adscititious on the sting of copper to avoid mechanical friction between the materials. The flexibility to mix triboelectric and CFRP materials provided a replacement approach to integrate energy harvest home into engineering structures and manufacture sturdy devices.

## B. Design Modules

### 1. WIRELESS CHARGING MODULE:

Wireless charging or inductive charging uses associate magnetism field to transfer energy between 2 objects. Here we tend to uses PTENG because the building blocks of energy. This can be typically through with a charging station. Energy that's made from the PTENG is distributed through a wireless module device, which may be then used for the charging of little wearable and electronic gadgets. Induction chargers generally use associate coil to form associate alternating magnetism field inside a charging base station. A second coil within the moveable device takes power from the magnetism field and converts it back to current.

Greater distances between sender and receiver coils may be achieved once the inductive charging system uses resonant inductive coupling. As we'd like to extend the vary the wireless transmission the amount of coils are accumulated and thereby increasing the vary of transmission up to a pair of feet.

Addition of additional (or larger) transmitter coils may extend the vary at that power may be transferred. Wireless charging is predicated on the principle of resonance or inductive power transfer, the method whereby electricity is transferred between 2 objects through coils victimization the subsequent key steps:

- Mains voltage is converted into high frequency AC.
- Mains voltage is regenerate into high frequency AC.
- The AC is distributed to the transmitter coil by the transmitter circuit. It then induces a time-varying field within the transmitter coil.
- The AC flowing at intervals the transmitter coil induces a magnetic flux that extends to the receiver coil.
- The magnetic flux generates current at intervals the receiver coil of the device. The method whereby energy is transmitted between the transmitter and therefore the receiver coil is additionally cited as magnetic or resonant coupling, and is achieved by each the coils reverberates at identical frequency.
- The AC current flowing at intervals the receiver coil is regenerate into DC by the receiver circuit, which may then be accustomed charge electronic gadgets. Fig. 1. Resonant wireless charging

## C. COMPARISON OF VARIOUS MODELS

Representative approaches	Advantages
Soft Tubular TENG	Sustainable power sources
Single Electrode-based TENG	30 LEDs were directly light
317L SS and ethyl cellulose	Sustainable energy supply
Integrated TENG	Self-powered systems

Table1. Various models and there advantages

## D. BLOCK DIAGRAM OF THE DEVICE

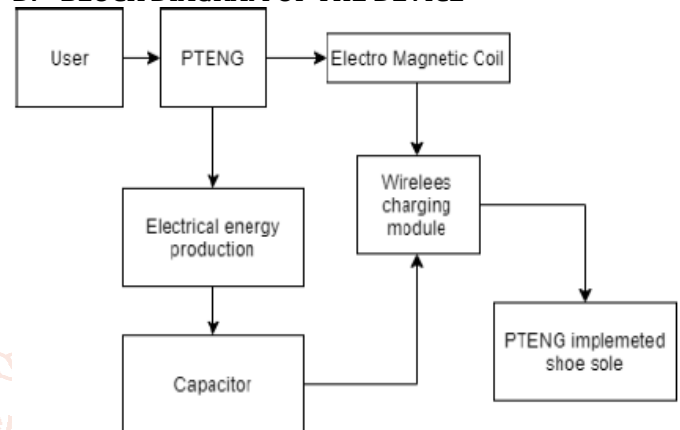


Fig.2. Block diagram

PTENG converts external energy into electricity by a conjunction of contact electrification and static induction. Static induction is that the main mechanism that converts energy into electricity. The contact evoked triboelectric charges will generated a possible drop once the 2 surfaces are separated by a mechanical force. Planned system can harvest energy for self-powered electronics in our lifestyle, which is able to have broad impact on people's living vogue within the close to future.

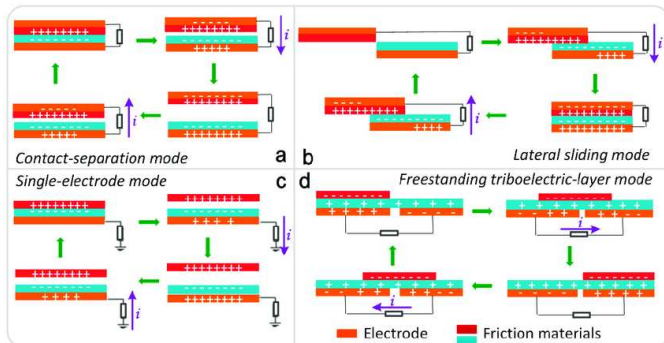
## V. DESIGN OF PROPOSED DEVICE

PTENGs are a vitality change technology as well as a multifunctional stage for creating self-powered sensor frameworks and adaptable/wearable electronics. Based on the piezo-triboelectric impact and electrostatic acceptance, PTENGs gather mechanical vitality from nature and convert it into power to control the coordinated electronic gadgets directly. Most TENGs are made out of two anodes, which join two sections of piezo-triboelectric materials with various triboelectric polarities for electric enlistment to shape a shut circuit for electron flow. The working principle of the TENG can be explained in two separate parts, which is based on the coupling effect of tribo electrification and electrostatic induction. Fig. 4.1 shows the working of the triboelectric nanogenerator.

During walking, the foot causes vertical pressure on the shoe sole so that, in this case, the best TENG working mode is the contact-separation mode. The electrical outputs for the different studies were recorded after 30 contact-separation cycles to stabilize the triboelectric charges. To take advantage of the area available on the shoe sole, parallel plate structure is used. The parallel plate's structure is composed by two plastic supports, a kapton tape and an aluminium foil tape that acts as the electrode. The distance between the two triboelectric materials is ensured using a sponge with a thickness of approximately 2 mm.



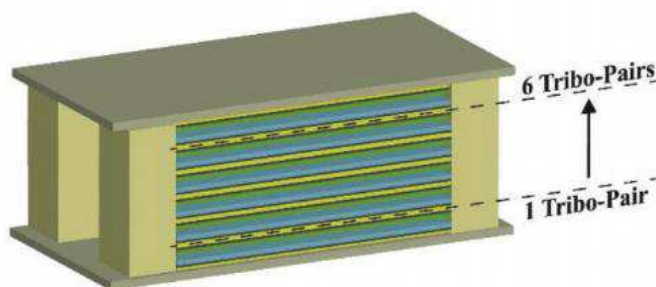
The structure with parallel plates showed the highest VOC values, reaching a maximum of approximately 30 V for an applied force of 430 N. To optimize the separation distance between the two triboelectric surfaces, the sponge thickness of the parallel plate's structure was varied from 0 to 8 mm. For the optimum thickness of the spacer, one obtains a maximum VOC of approximately 34 V (in the testing setup) and 14 V (within the shoe sole) for an applied force of 430 N and 390 N, respectively.



**Fig.3. Contact separation mode in the device**

This difference is due to the fact that the force applied on the device within the shoe sole is not as uniform as in the testing setup. VOC should increase with increasing sponge thickness, as this limits the distance between the two triboelectric layers. However, VOC decreases for sponge thicknesses higher than 2 mm, which is likely related with the decrease of the effective contact between the two triboelectric layers.

The optimum spacer thickness and the available height in the shoe sole (approx. 2.3 cm), this TENG have 1, 2, 3, 4, 5 and 6 tribo pairs to take full advantage of the available space inside of the shoe sole and maximize the energy generated by the TENG. The TENGs with the different tribo pairs are composed of the same triboelectric materials with the same dimensions, being the spacers between them the only modification. After these devices were constructed, we studied the performance of each one, measuring their electric outputs when connected to variable load resistances (from 100 Ohm to 470 Mega Ohm). All the presented results were obtained for an applied force of 322 N.



**Fig.4. Layer of tribo pair**

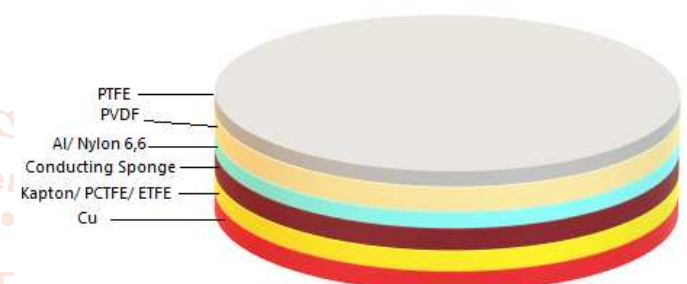
The open circuit voltage and short-circuit current generated by all devices, can be observed from the voltage and current increase with number of tribo pairs.

The maximum voltage increased from 26 to 92 V (254% higher), while the maximum current increased by approximately 239% (from 38 to 129  $\mu$ A). The electrical power obtained with 1, 2, 3, 4, 5 and 6 tribo pairs. The maximum power density occurs for all cases at a load

resistance of 1 M and for 1, 2, 3, 4, 5 and 6 tribo-pairs the maximum power density was approx. 0.30, 1.03, 1.93, 3.72, 3.85 and 3.91 W/m<sup>2</sup>, respectively. TENGs composed by 4, 5 and 6 tribo-pairs generated similar electrical outputs, which can be related to the increase of the sponge thickness that hinders the uniform contact between all the triboelectric layers.

The configurations with the highest electrical powers were those with 4 and 5 tribo-pairs. However, the height of these structures (1.4, 1.8 and 2.2 cm, respectively) limits the available space inside of the shoe sole to hybridize the TENG with other harvesting technologies to increase the obtained power output. Therefore, the final optimized prototype able to harvest energy from walking had a configuration with parallel plates composed by 3 tribo-pairs.

By using the above model as a base we are constructing a piezo-tribo nanogenerator as given below,



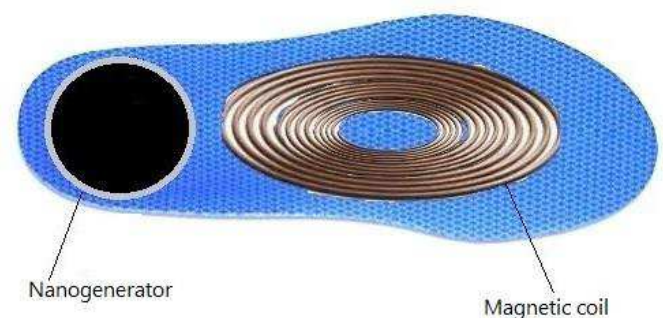
**Fig.5.1 piezo-tribo pair**

Total 4 piezo-tribo pairs will use in this model to get high output. Each layers have thickness as given below,

- Conducting sponge --- 2 mm
- Nylon 6,6 ----- 0.7874 mm
- Al ----- 0.1 mm
- PVDF ----- 6.35 mm
- PCTFE ----- 0.127 mm
- ETFE ----- 1.5748 mm
- Cu ----- 0.1 mm

A steady current is ensured during the compression and decompression phases as the piezo electric system delivers during the former phase while tribo electric system delivers during the later phase.

The model of shoe sole is shown below,



**Fig.6. Sole model**

## VI. RESULT AND ANALYSIS

To meet the great need for renewable and sustainable power sources, mechanical energy in the environment is widely used for electricity generation. In the proposed system a PTENG and EMG were hybridized to harvest the human

mechanical energy. There are various energy sources that may be harvested to power electronic devices. These include solar energy, mechanical energy, thermal energy and chemical energy etc. but with the diminution of energy sources and the need for using cleaner energy, alternatives must be found.

From this device each piezo-tribo pair will give 0.30 W/m<sup>2</sup> of power, 38  $\mu$ A of current and 26 V voltage. Total 4 piezo-tribo pairs will give 3.92 W/m<sup>2</sup> of power, 124  $\mu$ A of current and 90 V voltage.

User motion could also be recorded and discriminated using this energy cell. During normal walking, it could record the steps without any battery. A wireless signal transmitter could also work when driven by the energy cell. After several cycles of vibration, it could send a signal that would be received by a remote receiver. Afterwards, the nanogenerator was utilized to charge a small electronic gadgets. During vibration, the collected energy was stored in a capacitor, serving as a buffer. Small electronic gadgets will be wirelessly charged using the wireless module is build inside the shoe sole.

## VII. REFERENCES

- [1] Y. Zhou, D. J. Apo, and S. Priya, "Dual-phase self-biased magnetoelectric energy harvester," *Appl. Phys. Lett.*, vol. 103, no. 19, 2013, Art. no. 192909.
- [2] R. Gupta, M. Tomar, S. Rammohan, R. S. Katiyar, and V. Gupta, "Multiferroic cantilever for power generation using dual functionality," *Appl. Phys. Lett.*, vol. 109, no. 19, 2016, Art. no. 193901.
- [3] L. Zheng et al., "Silicon-based hybrid cell for harvesting solar energy and raindrop electrostatic energy," *Nano Energy*, vol. 9, pp. 291–300, 2014.
- [4] J. Chen et al., "All-plastic-materials based self-charging power system composed of triboelectric nanogenerators and supercapacitors," *Adv. Funct. Mater.*, vol. 26, no. 7, pp. 1070–1076, 2015.
- [5] M.-K. Kim, M.-S. Kim, S.-E. Jo, and Y.-J. Kim, "Triboelectric – thermoelectric hybrid nanogenerator for harvesting frictional energy," *Smart Mater. Struct.*, vol. 25, no. 12, 2016, Art. no. 125007.
- [6] Y. Hu, J. Yang, S. Niu, W. Wu, and Z. L. Wang, "Hybridizing triboelectrification and electromagnetic induction effects for high efficient mechanical energy harvesting," *ACS Nano*, vol. 8, no. 7, pp. 7442–7450, 2014.
- [7] C. Zhang, W. Tang, C. Han, F. Fan, and Z. L. Wang, "Theoretical comparison, equivalent transformation, and conjunction operations of electromagnetic induction generator and triboelectric nanogenerator for harvesting mechanical energy," *Adv. Mater.*, vol. 26, no. 22, pp. 3580–3591, 2014.

